

WHAT IS CLAIMED IS:

1. A system for separating particles from a contaminated liquid stream by flotation, comprising:

an apparatus for mixing the liquid with a separation enhancement additive and a gas;

a pressure reducing device in fluid communication with an outlet of the mixing apparatus for creating bubble laden floccs in the liquid;

a flotation tank having a bloom chamber and a separation chamber, the bloom chamber in fluid communication with an outlet of the pressure reducing device, the flotation tank being configured to direct the bubble laden floccs upwardly within the bloom chamber to an upper portion of the flotation tank and circulate the bubble laden floccs within the upper portion of the flotation tank until they rise to an upper surface of the flotation tank, and wherein the decontaminated liquid flows to a lower portion of the separation chamber of the flotation tank; and

a mechanism for removing the floated contaminate floccs from the upper surface of the flotation tank.

2. The system of claim 1, including a pressure sensor operably disposed between the mixing apparatus and the pressure reducing device.

3. The system of claim 2, including an adjustable valve disposed between the mixing apparatus and the pressure reducing device for altering the flow of liquid to the pressure reducing device.

4. The system of claim 1, wherein the mixing device comprises a reactor head having a gas injection port and a plurality of liquid ports configured to impart a spinning motion to the liquid as it passes to a downtube of the mixing apparatus.

5. The system of claim 4, wherein the liquid ports are configured to removably receive liquid flow restrictors, wherein the velocity and volume of the liquid passing through the mixing apparatus can be altered.

5                   6. The system of claim 1, wherein the pressure reducing device comprises an enlarged tube having a flow restrictor element therein.

7. The system of claim 6, wherein the flow restrictor element comprises an apertured plate.

10

8. The system of claim 7, wherein the size and the number of apertures in the plate are selected according to a predetermination of characteristics of the contaminated liquid.

15

9. The system of claim 1, including an adjustable wall disposed between the bloom chamber and separation chamber of the flotation tank.

10. The system of claim 1, including an apertured wall disposed within the separation chamber of the flotation tank above a floor thereof.

20

11. The system of claim 1, including a decontaminated liquid outlet formed in a lower portion of the flotation tank.

25

12. The system of claim 11, including a decontaminated liquid chamber in fluid communication with the lower portion of the flotation tank and the decontaminated liquid outlet and including an adjustable wall for selectively controlling the volume of decontaminated liquid removed through the outlet.

30

13. The system of claim 1, wherein the removing mechanism comprises a skimmer.

14. The system of claim 1, including a dewatering apparatus disposed relative to the flotation tank to receive and dewater removed contaminated floccs.

5                   15. A system for separating particles from a contaminated liquid stream by flotation, comprising:

                  an apparatus for mixing the liquid with a separation enhancement additive and a gas;

                  a pressure reducing device comprising an enlarged tube having a  
10               flow restrictor element therein, the device being in fluid communication with an outlet of the mixing apparatus for creating bubble laden floccs in the liquid;

                  a flotation tank having a bloom chamber and a separation chamber, the bloom chamber in fluid communication with an outlet of the pressure  
15               reducing device, the flotation tank being configured to direct the bubble laden floccs upwardly within the bloom chamber to an upper portion of the flotation tank and circulate the bubble laden floccs within the upper portion of the flotation tank until they rise to an upper surface of the flotation tank, and wherein the decontaminated liquid flows to a lower portion of the separation  
20               chamber of the flotation tank;

                  a decontaminated liquid outlet formed in a lower portion of the separation chamber;

                  a skimmer for removing the floated contaminate floccs from the upper surface of the flotation tank; and

25               a dewatering apparatus disposed relative to the flotation tank to receive the floated contaminate floccs from the skimmer and configured to dewater the removed contaminated floccs.

30               16. The system of claim 15, including a pressure sensor operably disposed between the mixing apparatus and the pressure reducing device.

17. The system of claim 16, including an adjustable valve disposed between the mixing apparatus and the pressure reducing device for altering the flow of liquid to the pressure reducing device.

5                    18. The system of claim 1, wherein the mixing device comprises a reactor head having a gas injection port and a plurality of liquid ports configured to impart a spinning motion to the liquid as it passes to a downtube of the mixing apparatus.

10                   19. The system of claim 18, wherein the liquid ports are configured to removably receive liquid flow restrictors, wherein the velocity and volume of the liquid passing through the mixing apparatus can be altered.

15                   20. The system of claim 15, wherein the flow restrictor element comprises an apertured plate, the size and the number of apertures in the plate being selected according to a predetermination of characteristics of the contaminated liquid.

20                   21. The system of claim 15, including an adjustable wall disposed between the bloom chamber and separation chamber of the flotation tank.

22. The system of claim 15, including an apertured wall disposed within the separation chamber of the flotation tank above a floor thereof.

25                   23. The system of claim 15, including a decontaminated liquid chamber in fluid communication with the lower portion of the flotation tank and the decontaminated liquid outlet and including an adjustable wall for selectively controlling the volume of decontaminated liquid removed through the outlet.

30

24. A system for separating particles from a contaminated liquid stream by flotation, comprising:

an apparatus for mixing the liquid with a separation enhancement additive and a gas;

5 a pressure reducing device in fluid communication with an outlet of the mixing apparatus for creating bubble laden floccs in the liquid, the device comprising an enlarged tube having an apertured plate therein, the size and number of the apertures in the plate selected according to a predetermination of characteristics of the contaminated liquid;

10 a pressure sensor operably disposed between the pressure reducing device and the mixing apparatus;

an adjustable valve disposed between the pressure reducing device of the mixing apparatus for altering the flow of liquid to the pressure reducing device;

15 a flotation tank having a bloom chamber and a separation chamber separated by an adjustable wall, the bloom chamber in fluid communication with an outlet of the pressure reducing device, the flotation tank being configured to direct the bubble laden floccs upwardly within the bloom chamber to an upper portion of the flotation tank and circulate the bubble  
20 laden floccs within the upper portion of the flotation tank until they rise to an upper surface of the flotation tank, and wherein the decontaminated liquid flows to a lower portion of the separation chamber of the flotation tank;

a decontaminated liquid outlet formed in a lower portion of the separation chamber;

25 a skimmer for removing the floated contaminate floccs from the upper surface of the flotation tank; and

a dewatering apparatus disposed relative to the flotation tank to receive the floated contaminate floccs from the skimmer and configured to dewater the removed contaminated floccs.

25. The system of claim 24, wherein the mixing device comprises a reactor head having a gas injection port and a plurality of liquid ports configured to impart a spinning motion to the liquid as it passes to a downtube of the mixing apparatus, wherein the liquid ports are configured to removably receive liquid flow restrictors, wherein the velocity and volume of the liquid passing through the mixing apparatus can be altered.

26. The system of claim 24, including an apertured wall disposed within the separation chamber of the flotation tank above a floor thereof.

27. The system of claim 24, including a decontaminated liquid chamber in fluid communication with the lower portion of the flotation tank and the decontaminated liquid outlet and including an adjustable wall for selectively controlling the volume of decontaminated liquid removed through the outlet.

28. A method for separating particles from a contaminated liquid stream by flotation, comprising the steps of:

mixing the liquid with a separation enhancement additive and a gas;  
creating bubble laden floccs in the liquid by reducing the pressure of the mixed liquid stream using a pressure reducing device;

directing the bubble laden floccs upwardly into a bloom chamber of a flotation tank;

circulating the bubble laden floccs in an upper portion of a separation chamber of the flotation tank until they rise to an upper surface of the flotation tank, wherein the decontaminated liquid flows to a lower portion of the separation chamber of the flotation tank; and

removing the floated contaminate floccs from the upper surface of the flotation tank.

29. The method of claim 28, wherein the mixing step comprises imparting a spinning motion to the liquid using a mixing apparatus having a reactor head including a gas injection port and a plurality of liquid ports in fluid communication with a downtube of the mixing apparatus.

5

30. The method of claim 30, including the step altering the velocity and volume of the liquid passing through the mixing apparatus by restricting the flow of liquid through the liquid ports.

10

31. The method of claim 28, wherein the creating step includes the step of passing the mixed liquid through a pressure reducing device comprised of an enlarged tube having a flow restrictor element therein.

15

32. The method of claim 31, wherein the flow restrictor element comprises an apertured plate

20

33. The method of claim 32, including the step of selecting the size and the number of apertures in the plate according to a predetermination of characteristics of the contaminated liquid.

25

34. The method of claim 31, including the steps of monitoring the pressure of the liquid stream, and altering the flow of liquid to the pressure reducing device.

30

35. The method of claim 28, including the step of adjusting a wall disposed between the bloom chamber and separation chamber of the flotation tank.

36. The method of claim 28, including the step of passing the decontaminated liquid through an apertured wall disposed within the separation chamber of the flotation tank above a floor thereof.

37. The method of claim 28, including the step of removing the decontaminated liquid through an outlet formed in a lower portion of the flotation tank.

5                   38. The method of claim 37, including the step of passing the decontaminated liquid through a chamber in fluid communication with the lower decontaminated liquid outlet, and adjusting wall within the chamber to selectively control the volume of decontaminated liquid removed through the outlet.

10                   39. The method of claim 28, wherein the removing step includes the step of skimming the upper surface of the flotation tank.

15                   40. The method of claim 28, including the step of dewatering the removed contaminated floccs.

41. A method for separating particles from a contaminated liquid stream by flotation, comprising the steps of:

20                   mixing the liquid with a separation enhancement additive and a gas using a mixing apparatus having a reactor head including a gas injection port and a plurality of liquid ports configured to impart a spinning motion to the liquid as it passes from the reactor head to a downtube of the apparatus;

25                   creating bubble laden floccs in the liquid by reducing the pressure of the mixed liquid stream using a pressure reducing device comprised of an enlarged tube having a flow restrictor element therein;

                  altering the flow of the liquid stream to the pressure reducing device based on a monitoring of the pressure of the liquid stream;

                  directing the bubble laden floccs upwardly into a bloom chamber of a flotation tank;

30                   circulating the bubble laden floccs in an upper portion of a separation chamber of the flotation tank until they rise to an upper surface of



the flotation tank, wherein the decontaminated liquid flows to a lower portion of the separation chamber of the flotation tank;

removing the decontaminated liquid through an outlet formed in a lower portion of the flotation tank;

5

removing the floated contaminate floccs from the upper surface of the flotation tank using a skimmer; and

dewatering the removed contaminated floccs.

10

42. The method of claim 41, including the step altering the velocity and volume of the liquid passing through the mixing apparatus by restricting the flow of liquid through the liquid ports.

15

43. The method of claim 41, wherein the flow restrictor element comprises an apertured plate

20

44. The method of claim 43, including the step of selecting the size and the number of apertures in the plate according to a predetermination of characteristics of the contaminated liquid.

25

45. The method of claim 41, including the step of adjusting a wall disposed between the bloom chamber and separation chamber of the flotation tank.

30

46. The method of claim 41, including the step of passing the decontaminated liquid through an apertured wall disposed within the separation chamber of the flotation tank above a floor thereof.

47. The method of claim 41, including the step of passing the decontaminated liquid through a chamber in fluid communication with the lower decontaminated liquid outlet, and adjusting wall within the chamber to selectively control the volume of decontaminated liquid removed through the outlet.

5